

Decomposing Trends in U.S. Greenhouse Gas Emissions

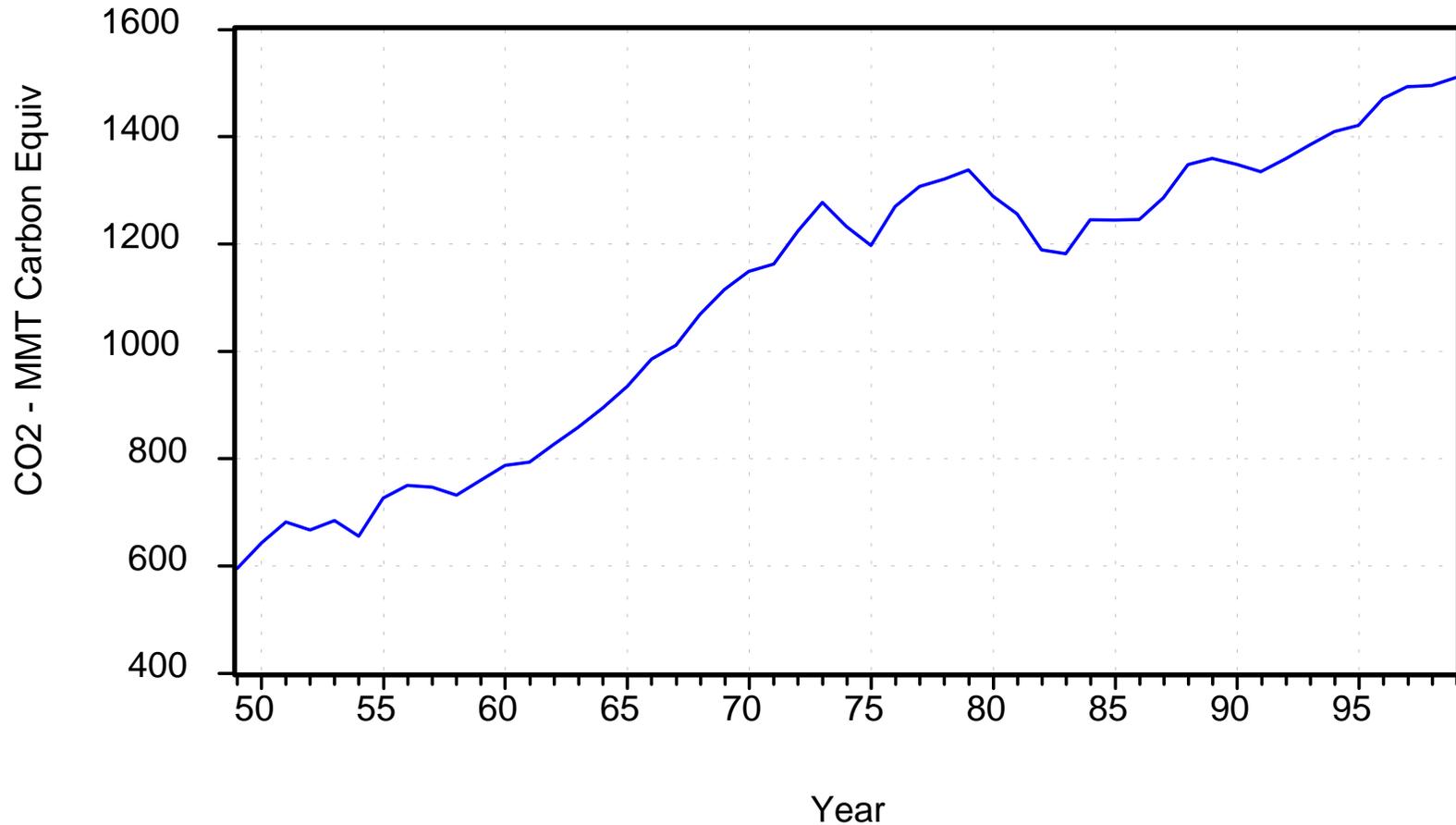
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**presented to the
10th Annual Emission Inventory Conference:
One Atmosphere, One Inventory, Many Challenges
Denver, Colorado
May 2, 2001**

Purpose of Analysis

- Examine Trends in U.S. Carbon Dioxide (CO₂) Emissions (1949-99)
- Identify Breaks in Long-term Trend
- Highlight Factors that Produce Short-term Deviations in Trend
 - Short-term Analysis, 1997-1999
 - Long-term Analysis, 1949-1999; 1967-99

U.S. Carbon Dioxide Emissions, 1949-99



Source: Energy Information Administration

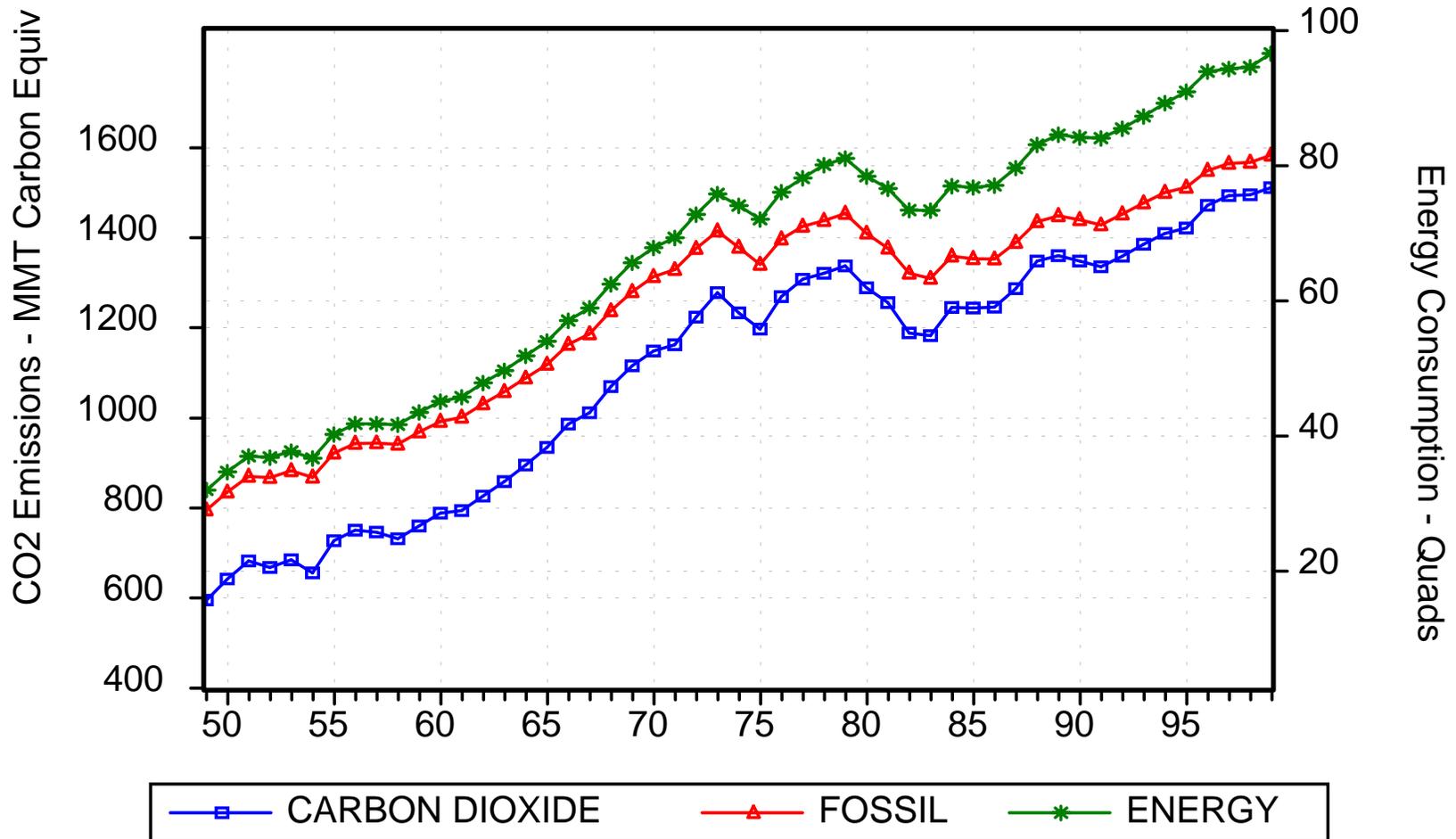
U.S Carbon Dioxide Emissions Trend Growth 1949-99 and by Decade

Years	Compound Avg. from Endpoints	Log-linear Estimate
1949 - 99	1.9%	1.8%
1950 - 59	1.9%	1.8%
1960 – 69	3.9%	4.0%
1970 – 79	1.7%	1.5%
1980 – 89	0.6%	0.9%
1990 – 99	1.3%	1.5%

Factors Influencing Long-term Trend in U.S. CO₂ Emissions

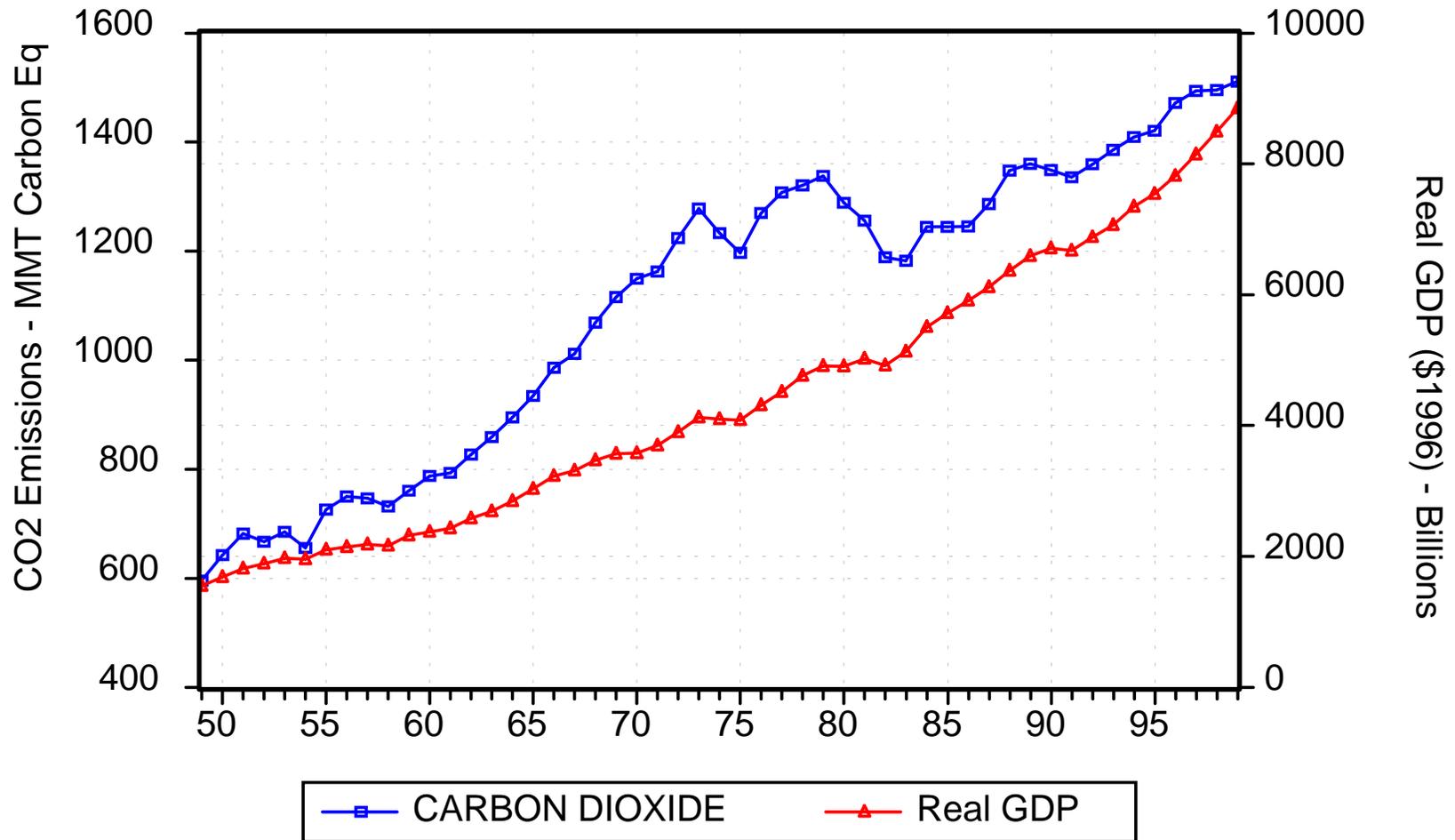
- Economic Growth
 - Population growth
 - Productivity growth
 - Income growth
- Energy Use
 - Energy Use As a Function of GDP Growth
 - Fossil-fuel Combustion Produces
 - 98% of Total U.S. CO₂ Emissions
 - 82% of Total U.S. GHG Emissions

U.S. CO₂ Emissions and Energy Use, 1949-99



Source: Energy Information Administration

U.S. CO₂ Emissions and GDP 1949-99



Source: Energy Information Administration

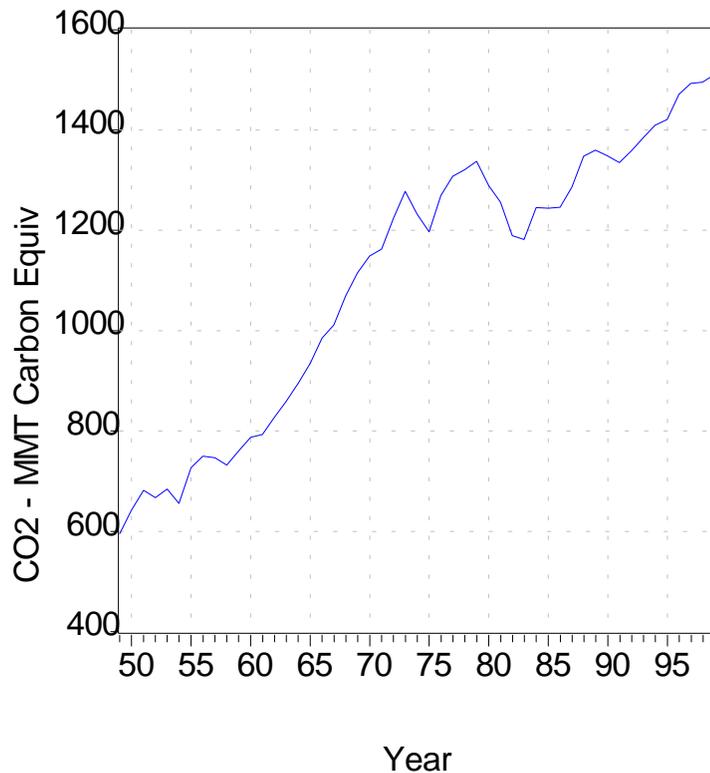
Percent of Variation in CO2 Emissions Explained by Energy Consumption or GDP, 1949 - 1999

Functional Form	Adjusted R²
$CO_2 = f(\text{Fossil Use})$	99.60%
$CO_2 = f(\text{Energy Use})$	99.57%
$CO_2 = f(\text{Real GDP})$	85.59%

Factors Creating Breaks in Long-term CO₂ Emission Trends

- Increased Energy Efficiency
 - More energy efficient technologies
 - Substitution from energy to other factors of production (capital, labor and/or materials)
- Decreased Energy Intensity
 - Increased share of less energy-intensive goods
- Increased use of less carbon-intensive fuels

Econometric Tests Indicate Trend Break in CO2 Emissions



- Chow test (1949-79; 1980-83; 1984-99)
- CUSUM (1949-89; 1990-99)
- CUSUM Squares (1949-61; 1962-84; 1985-99)
- Recursive Residuals (1949-79; 1980-86; 1987-99)

Trend Growth Rates in CO2 Emissions for Selected Periods

Time Period	Log-linear Growth Rate
1949 - 1979	2.8%
1980 - 1986	- 0.3%
1987 - 1999	1.3%

Factors that Can Produce Short-term Deviations in CO₂ Emissions Trends

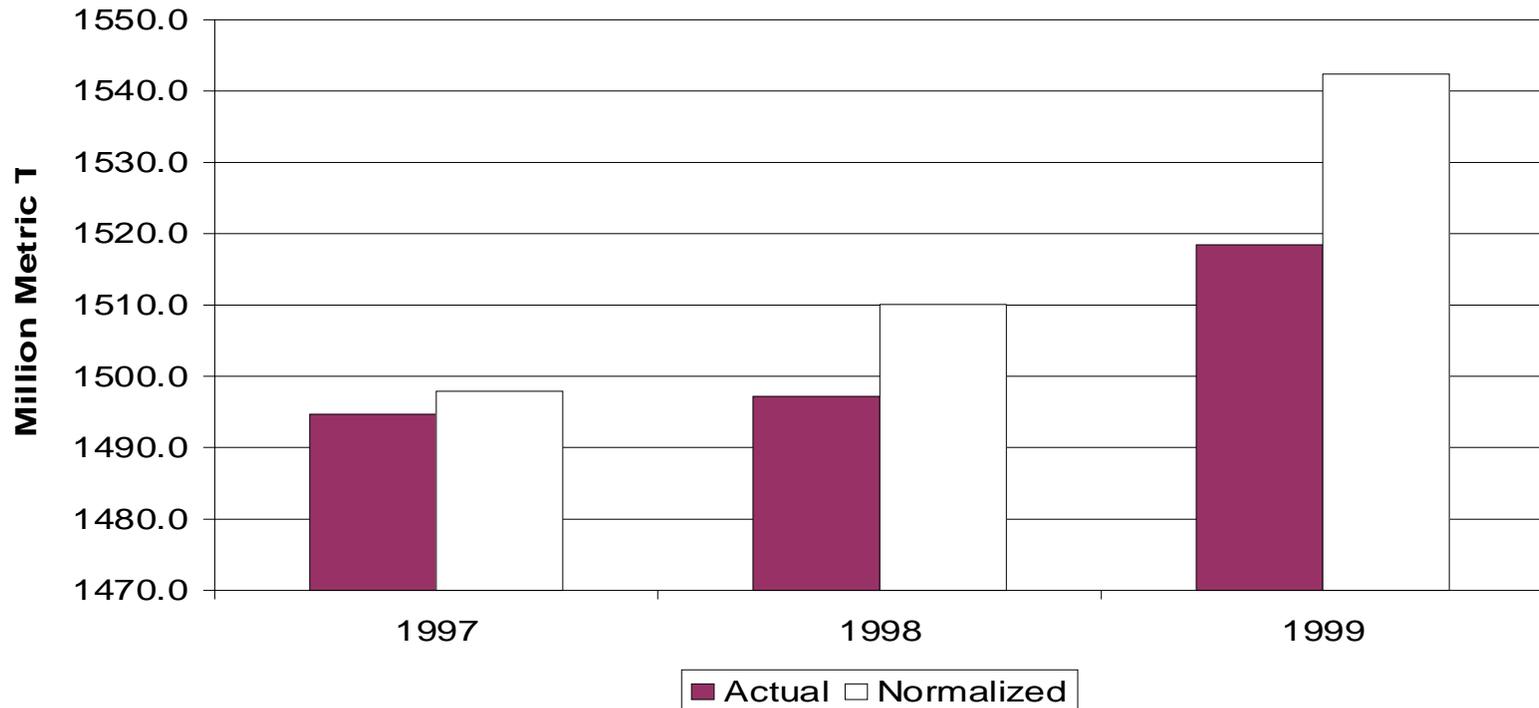
- Weather
 - Heating Degree Days (HDD)
 - Cooling Degree Days (CDD)
- Non-fossil Fueled Power Generation
 - Nuclear Power
 - Hydroelectric Power
- Fossil fuel prices
- Production of Energy-intensive Products
- Other ? (e.g., High-tech goods - computers, semiconductors, etc.)

Short-term Analysis of Deviations in CO₂ Trends

- Performed using EIA's Short-term Integrated Forecasting System (STIFS)
- Compared 1997-1999 CO₂ Emissions under:
 - Actual/Base Simulation (Using actual 1997-1999 variable values)
 - Normalized Simulation (Using normal/expected 1997-1999 variable values)
 - HDD; CDD; Nuclear Gen., Hydro Gen., Oil prices; Energy-intensive Industry Output

Short-term Simulation Results 1997 - 1999

U.S. Carbon Emissions



Short-term Simulation Results 1997 - 1999 (cont.)

CO₂ Emissions Deviations From “Normalized” Trend (MMT Carbon Equiv.)

Year	Total	Weather Total	HDD	CDD	Macro	Oil Price	Nuc/ Hydro
1997	-3.2	-3.7	0.0	-3.7	3.7	0.3	-3.5
1998	-12.9	-10.1	-20.0	9.9	3.3	0.8	-6.9
1999	-24.0	-11.3	-14.3	3.0	4.2	-0.3	-16.6

Long-term Analysis of Deviations in CO₂ Emissions Trends

- Two periods examined:
 - 1949 - 1999 (EIA data available)
 - 1967 - 1999 (Hi-tech production data available)
- Purpose:
 - To identify likely factors that produce deviations in CO₂ emissions trends
 - To quantify impacts of those factors

Functional Form of Estimated Equations

- 1949 - 1999:
 - $CO_2 = a + (c1*time + c2*time^2; \text{detrrending term}) + f(\text{HDD, CDD, Nuclear/Hydro Share of Total Generation, Energy-intensive Industries' Share of Total GDP, Composite Real Fossil Fuel Production Prices})$
- 1967 - 1999
 - Same as above except includes variable on High-tech Output Share of GDP

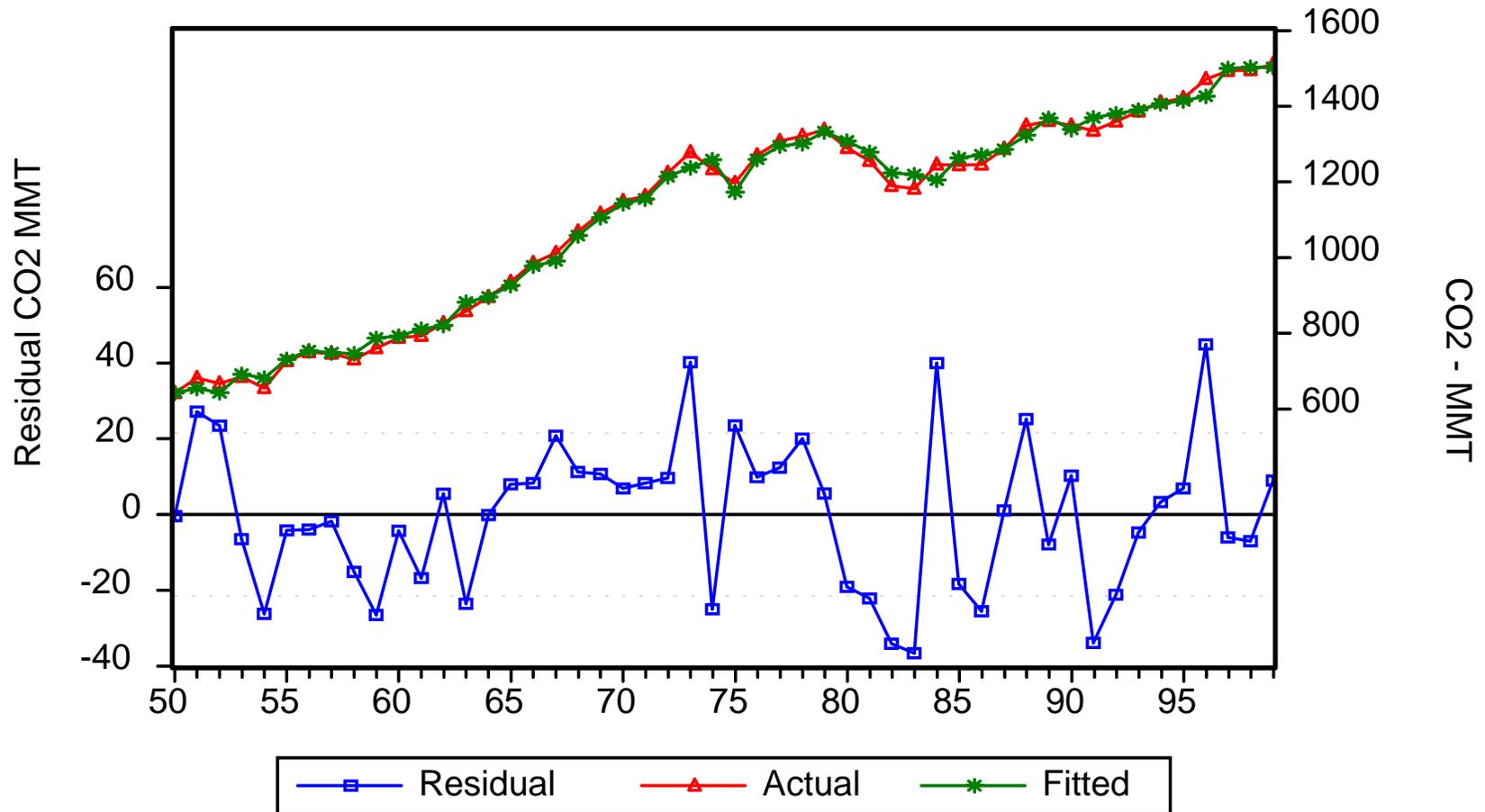
Long-term Analysis

1949-1999 Preliminary Results¹

Variable	Coefficient	Meaning
HDD	0.025	100 HDD Increase = 2.5 MMT Increase
CDD	-0.016	Incorrect Sign/ Not Significant
Nuclear/Hydro Share of Total Generation	-10.090	1% Share Increase = 10.1 MMT Decrease
Energy Intensive Industries Share of GDP	60.102	1% Share Increase = 60.1 MMT Increase
Real Composite Fossil Fuel Production Prices	-25.686	\$1/MMBtu Increase = 25.7 MMT Decrease

¹Note: Results are preliminary, apply on average only to the 1949-99 period, and are not necessarily applicable for forecasting purposes.

Long-term Analysis 1949-1999 Preliminary Results



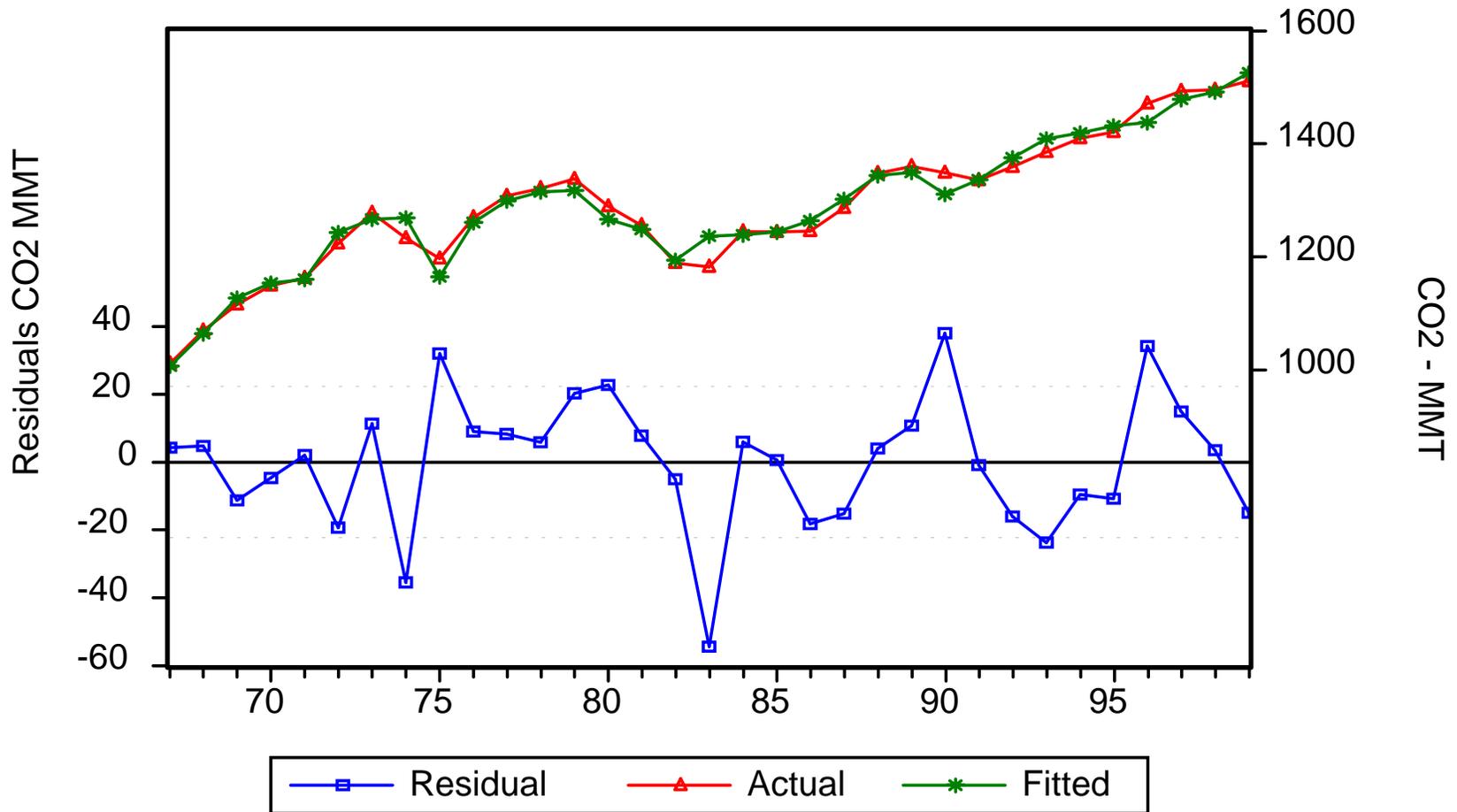
Long-term Analysis

1967-1999 Preliminary Results¹

Variable	Coefficient	Meaning
HDD	0.049	100 HDD Increase = 4.9 MMT Increase
CDD	0.005	Correct Sign/ Not Significant
Nuclear/Hydro Share of Total Generation	-7.485	1% Share Increase = 7.5 MMT Decrease
Energy Intensive Industries Share of GDP	125.0	1% Share Increase = 125.0 MMT Increase
Hi-Tech Share of GDP	11.755	Incorrect Sign ? / Significant
Real Composite Fossil Fuel Production Prices	-29.646	\$1/MMBtu Increase = 29.6 MMT Decrease

¹Note: Results are preliminary, apply on average only to the 1967-99 period, and are not necessarily applicable for forecasting purposes.

Long-term Analysis 1967-1999 Preliminary Results



Conclusions

- Econometric Tests Indicate 2 to 3 Long-term Trend Breaks in U.S. CO₂ Emissions during the 1949-99 time frame:
 - 2.8% growth from 1949-79
 - -0.3% growth from 1980-86
 - 1.3% growth from 1987-99
- Short-term deviations from trend can occur in any given year

Conclusions (cont.)

- Short-term deviations driven by:
 - weather; nuclear/hydro generation, energy-intensive industries, fossil fuel prices
- During 1997-99, short-term deviations reduced CO₂ emissions from “expected” levels
 - 1997 (3.2 MMT); 1998 (12.9 MMT); 1999 (24.0 MMT)
- Analysis of 1949-99 data also indicate presence of short-term deviations